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WORLD SCANNER REPORT

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SUPERSNOOP TRANSMITTER

~ The Saga Continues ~

A reader recently complained about our SuperSnoop series, wondering what the hell it had to do with scanning. Well, this month's installment should yield a clue or two. Think about it.

First, we presented the SuperSnoop microphone, so sensitive, it's capable of detecting the heavy breathing of a couple of gnats making whoopee at a distance of 73 yards. But what's so hot about a super sensitive microphone without an amplifier to boost the weak signals to speaker-playback volume?

So, last month, I laid on you the SuperSnoop Amplifier. Together, the SuperSnoop Microphone & SuperSnoop Amplifier are a very potent dynamic duo that stand on their own merits.

But what about times when you are *persona non-grata* and need or want to listen in on what's going on? The presence of your magnificent personage can be distracting to the goings-on, but if you could be remotely located and still hear, then so much the better, right?

Take you parents, fer instance. You might use a baby monitor to keep tabs on Junior and Queenie as they sleep. When they get older, the baby monitor can be moved to the rumpus room so you can keep tabs on how much blood is being drawn at any given time.

Trouble is.....baby monitors are never as good as they're cracked up to be. They don't sound all that good for one thing. The units are large and bulky and cannot be operated from batteries. They're definitely not portable, nor very well suited for clandestine and treacherous situations. Baby monitors do not make very good bugs for a variety of reasons.

Not that I am advocating the fine arts and sciences of surreptitious bugging; I most assuredly am not! But there are some very legitimate needs to know what's going on in situations where it's ill advised to have others privy to your eavesdropping.

Take fer instance that peephole in your front door. It's nice to know what's going on outside your door before you open it. It's nice to know what's going on all around your property before you jump into the middle of something with both feet. But peepholes aren't always available, and neither do they serve the purpose in all instances.

My SuperSnoop series can add an immense measure of security to your home and family. In many instances, just the microphone and amplifier will suffice. You could embed several Microphones out of sight around your property; feed their outputs into the Amplifier through a rotary switch so as to afford the capability of listening to key areas around your perimeter. Power can be fed by a cheap DC Adapter.

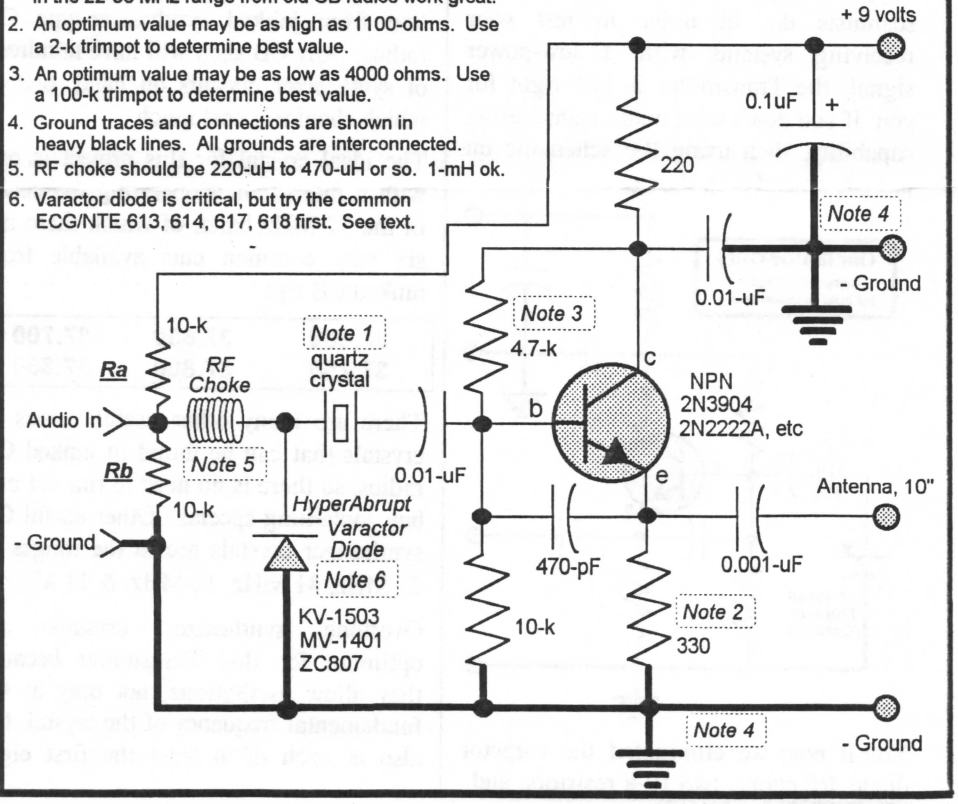
But wired listening devices are not always suited to given situations. Sometimes, radio is ideal, and that's where this month's SuperSnoop Transmitter and a scanner enter the picture. The output of the SuperSnoop Amplifier can be fed to the input of the SuperSnoop Transmitter for a superb, ***high quality*** radio listening device!

Do NOT mistake my words here....we are talking ***quality***! I'm sure a lot of you guys have experimented with Radio Shack's listening device, #33-1076, the FM Wireless Mic. Cute, but no cigar. Poor range and low sensitivity. Eats batteries, too.

SUPER SNOOP TRANSMITTER

NOTES:

1. The crystal isn't critical, but probably shouldn't be lower than 10 MHz, nor higher than 50 MHz. Synthesizer crystals in the 22-38 MHz range from old CB radios work great!
2. An optimum value may be as high as 1100-ohms. Use a 2-k trimpot to determine best value.
3. An optimum value may be as low as 4000 ohms. Use a 100-k trimpot to determine best value.
4. Ground traces and connections are shown in heavy black lines. All grounds are interconnected.
5. RF choke should be 220-uH to 470-uH or so. 1-mH ok.
6. Varactor diode is critical, but try the common ECG/NTE 613, 614, 617, 618 first. See text.



Make no bones about it, my SuperSnoop Transmitter will knock your socks off when you hear its quality. There is no doubt in my mind this little puppy will equal or exceed the quality of pro-snoop devices! It's unbelievable! But true!

THE SECRET UNVEILED!

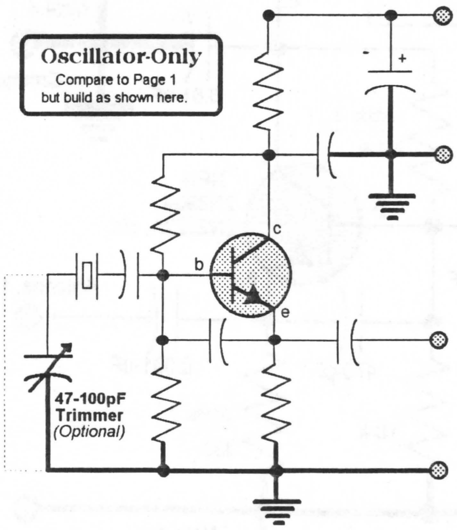
First, I gave you the Microphone. It's eminently useful as a stand-alone device, say with tape recorders or as a feed to an amplifier. Now just in case you didn't have an amplifier handy, I gave you the SuperSnoop Amplifier to take up the slack. Now, we add the transmitter, for one whopper of a listening device when remote operations are needed. I have been spoonfeeding you a system!

But we're not ready for the system yet. The Microphone was a stand-alone project, as was the Amplifier. So, too, is the transmitter! Never mind this month that the Microphone and Amplifier can drive the Transmitter. This month, the general idea is as another stand-alone project.

Next month, I will wrap it up for you into a single, unitary system project. This month, we just focus on the Super Snoop Transmitter for whatever purpose and use you can find for it. And there are several, not including any audio capabilities.

SUPERSNOOP TRANSMITTER

If you need *just an oscillator*, as many scannists do, in order to test your receiving systems with a low-power signal, the Transmitter is just right for you. If you don't need audio transmitting capability, then using the schematic on page 1, amend it as shown:



You'll note we eliminated the varactor diode, RF choke; two 10-k resistors; and a bit of wiring. In a word, the basic Transmitter is super easy to build, and if you need to transmit high quality audio, the required "extras" are not a big deal. The rest of this project will deal with the Transmitter as if audio were needed, but you needn't get hung up on that, if all you need is a source of RF with which to test your receivers. In that case, build the circuit as shown on this page, and use a small trimmer capacitor by which to precisely adjust the frequency if needed. You can just ground that end of the crystal, too, and dispense with the trimmer capacitor, as shown by the dotted line, if you don't need precision tweaking capability.

THE HEART OF IT ALL

Our transmitter is just a basic crystal oscillator, garden variety, nothing special. In fact, it's so unspecial that it's slicker than snake snot smeared on ice. High quality oscillators put out only one frequency. Ours puts out a ***bunch*** of frequencies. More on that later.

The heart-throb of the Transmitter is, of course, the quartz crystal, and it's not critical aside from maybe two things:
(1) Frequency should not be higher than about 40-50 MHz, nor lower than about 8 MHz. You'll see why in a minute. And (2), the crystal should be of the *3rd Overtone* type, though really, most any "rock" will do. The neat thing about overtone crystals is that you can salvage 'em from junked synthesizer-type CB radios. Any CB shop will have hundreds of synthesizer crystals on hand, one of which shouldn't cost much.

The ideal crystal for this project is one with a fundamental operating frequency in the 37 MHz band, of which there are six very common cuts available from junked CB rigs:

37.600	37.650	37.700
37.750	37.800	37.850

There are many other useful values of crystals that can be found in junked CB radios, so there is no need to run out and buy something special. Other useful CB synthesizer crystals are in the ranges of 23 MHz, 41 MHz, 16 MHz, & 11 MHz.

Overtone synthesizer crystals are optimum for this Transmitter because they allow oscillations, not only at the fundamental frequency of the crystal, but also at each of at least the first eight harmonics of the fundamental. This usually unsavory characteristic is what lets us use a variety of crystals, down to 8 MHz or so. (*Harmonics are multiples of the fundamental!*)

Let's suppose you used a crystal with a fundamental of 11.500 MHz. The useful harmonics would be: 23.0, 34.5, 46.0, 57.5, 69.0, 80.5, and 92.0 MHz, or even higher. That's right, the oscillator will generate all these frequencies and maybe even more. So while the fundamental and 2nd harmonic frequencies are not covered by most scanners, the 3rd and higher harmonics are....and when your scanner is tuned to one, there will be no doubt in your confused mind that you're getting a signal. It won't take long for you to learn how to use those signals to test and evaluate your scanners. And if you feed the Transmitter with a source of audio, it will act a lot like a baby monitor.

THE BRAIN & NERVES

If the crystal is the heart of an oscillator, then the varactor diode (or trimmer capacitor) is the brain and nervous system. Now if all you want is a transmitter (without audio), then forget the varactor diode and just use a trimmer capacitor as shown on this page. Or, don't use one, if precision adjustment of frequency is not necessary. With the left side of the crystal grounded as shown by the dotted line, the crystal will use its internal capacitance to set a resonant frequency (and harmonics). An external capacitor simply allows precision setting of the resonant frequency. It's up to you.

The Varactor Diode is the most critical component if you want a high quality audio transmitter. Varactors are basically silicon diodes, but made in a special manner that makes them act like variable capacitors when reverse biased. The amount of capacitance varies according to the level of the reverse bias voltage. By the way, all silicon diodes exhibit a varactor effect to some degree, but only "real" varactors can be used for our purpose. And even then, not just any varactor will do, though you can experiment cheaply enough.

Before I get into the SuperWhizBang type of varactor that you really want, let's take a quick look at what can be used for the sake of experimenting. You might never have heard of varactor

ECG/NTE Varactor Tuning Diodes

NTE or ECG Part No.	DIAG NO.	NOMINAL DIODE CAPACITANCE @ VR = 4 V, f = 1 MHz	TYPICAL TUNING RATIO C2/C30 @ f = 1 MHz	MAX REVERSE BREAKDOWN VOLTAGE	MAX FORWARD CURRENT	MAX DEVICE DISSIPATION	MIN FIGURE OF MERIT @ V_R = 4 Vdc, f = 50 MHz
		CT Pf	TR	BV_R Volts	I_F mA	P_D Watts	Q
610	109	6.8	2.7	30	200	280	450
611	109	10.0	2.9	30	200	280	400
612	109	12.0	2.9	30	200	280	400
613	109	22.0	2.9	30	200	280	350
614	109	33.0	3.0	30	200	280	200

NTE or ECG Part No.	DIAG NO.	APPLICATION	Reverse Breakdown Voltage	Maximum Forward Current I_F	Power Dissipation	Minimum Figure of Merit	Diode Capacitance C_T	Capacitance Ratio
			Volts	mA	mW	Q	pF	
617	394	FM Tuning	32	200	280	100 @3 V	34 (min) @ 3 V	2.5 min
618	393	AM Tuning	18	50	280	150 @ 1 V	440 (min) @ 1 V	15

tuning diodes, but they are as common as fleas on a junkyard dog. Go to your local semiconductor supply house and buy one each of the following ***ECG*** or ***NTE*** part numbers: the cost is modest.

613	614	617	618

One of these may work quite well, and if so, your search will be neither lengthy nor costly. I can't attest to these varactors because I use a more costly commercial version that I'll tell you about in a minute. To my way of thinking, if the above work, then let's use the KISS principle. NTE/ECG suppliers are everywhere. Sources for my special varactor diodes are few and far between. The above are common and inexpensive.

The chart at the top of this column offers clues on what varactor diodes do and how they function. In a word, they act like the "trimmer capacitor" shown on the previous page. The capacitance varies with the reverse bias placed on the diode. (*Varactor diodes are never forward biased....that is, we do not want them to conduct!*)

Instead, we want to send an audio (AC) voltage to the varactor in such a manner that its reverse bias changes at the audio rate. When this happens, the output frequency of the oscillator will also change at the same rate. Voile! FM! <u>F</u>requency <u>M</u>odulation - for clear, noise-free signals that can be readily received by common scanner receivers!

Note the trimmer capacitor used in the drawing on the previous page? As said before, a varactor acts like a trimmer capacitor, except that you adjust it by changing the reverse bias voltage on the diode. Now understand that crystals "like" to be grounded, but happily tolerate some capacitance in the ground side. The more capacitance, the better, though. Too little, and the crystal will not oscillate. Therefore, we can't use just any trimmer capacitor nor just any varactor diode. Either one must have a certain minimum capacitance, so our job is to select something that will not cause any problems with oscillation. It just so happens that **<u>20-pF</u>** or more capacitance is usually sufficient to stabilize a crystal oscillator. Looking at the above chart, we see where ECG/NTE 610-612 fall under this mark, so we won't consider them for our transmitter. However, 613, 614, 617, and 618 look pretty good.

Another important thing about varactor diodes is the ***tuning ratio***. A very narrow change of capacitance relative to the reverse bias means a small tuning ratio. This may not be sufficient to frequency modulate the transmitter. So we want a fairly large tuning ratio, as well. Diodes 613, 614, and 617 have tuning ratios of 2.5 to 3.0, while 618 has a whopper 15. Were it not for the "AM Tuning" spec, I'd say go for 618. As it is, the large 440-pF capacitance coupled with the AM-spec might render this one unsuitable for our needs, Try it, Otherwise, my gut feel for a workable varactor diode is the 617. One of the four might yield satisfactory results.

Hyper-abrupt Tuning Diodes

As mentioned earlier, I use a special type of varactor tuning diode called ***Hyper-Abrupt***. Forgive me for not explaining it in detail, but space begs and it gets kind of complicated. Suffice it to say that this diode yields performance ***par excellence***! That's why I prefer the KV1503 from **Frequency Sources.** The MV1401 or ZC807 from MSI Electronics should also work equally well, though I have not tried those from MSI. But before you go to these commercial suppliers, there is one other source for the superb kind of diode I am talking about.

You die-hard CB'ers and Freebanders will know of a special tuning diode used to extend the range of SSB clarifiers or "sliders". Once upon a time, known as the "M-15 diode", "Super Slider Diode", "Super Tune Diode" and a variety of other colloquial names, these special diodes will serve the purpose in our SuperSnoop Transmitter. So check your CB/hack resources for one of these diodes, if need be. Otherwise, contact:

Frequency Sources 16 Maple Road Chelmsford, MA 01824 (617) 256-8101 Fax (617) 256-8227	***KV-1503 diode***
MSI Electronics 34-32 57th Street Woodside, NY 11377 (718) 672-6500 Fax (718) 397-0972	***MV-1401 diode*** ***ZC807 diode***

You should expect to pay an arm and a leg from the above sources, but maybe prices have dropped since I last purchased. If you run into a roadblock finding just the right diode, I have a small quantity of the KV-1503 and equivalents that I can let go for just a leg. See the end of this article for what I can supply.

CLOSING NOTE ON VARACTORS

Don't let these puppies intimidate you. I've explained everything you need to know about varactor tuning diodes. Just hook the sucker up right, if you expect it to work.....which means the anode is grounded and the cathode (banded end) goes to the crystal.

BIAS CIRCUIT & RF CHOKE

An audio signal of several volts is fed to the oscillator as shown on page 1. The audio readily passes through the RF choke to the cathode of the varactor where it can change the capacitance as discussed. The RF choke isolates the RF crystal signal from the audio circuit, however, and is very important! A minimum of 220-uH is required, with 470-uH or even 1-mH being just fine. We do not want RF leaking back into the audio circuits. *Chokes block RF.*

Notice the two 10-k resistors, ***<u>Ra</u>*** & ***<u>Rb</u>***? The top of Ra goes to the +9v DC source while the bottom of Rb is grounded. This means that 4.5-v is dropped across

each resistor, placing a +4.5v bias on the cathode of the varactor diode. But cathodes need a negative voltage to make the diode conduct! This is what I mean by ***reverse bias***. It prevents the diode from conducting, even with audio signals as high as 9-v, peak-to-peak.

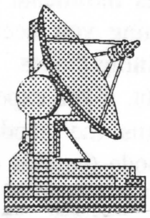
If you don't understand this hocus-pocus, don't worry.....just build the circuit as shown and do not change or deviate from the Ra/Rb/RF Choke circuit as shown.

THE REST OF THE CIRCUIT

Everything else is fairly standard and needs no special discussion here. The transistor is not critical, but should be rated for operation up to 100 MHz or so. The 2N3904 or 2N2222A are known to work quite well in the Transmitter.

The 4.7kΩ (Note 3) and 330Ω (Note 2) resistors can be somewhat critical with respect to the output power of the oscillator. If you want to optimize or peak this power, then start your design with a 100-kΩ trimpot in place of the 4.7kΩ resistor and a 2kΩ trimpot in place of the 330Ω resistor. Preset them to 4.7kΩ and 330Ω respectively, and later, you can adjust them for maximum signal strength at a remote receiver. Then replace the trimpots with fixed resistors of the values measured after the adjustments.

MORE TECHNICAL



The SuperSnoop Transmitter requires several volts of audio signal on the cathode of the varactor diode in order to adequately FM-modulate the oscillator. By and large, the "loudness" of FM modulated signals is dependent on how much the input signal *deviates* the RF carrier. Varactor diodes are not known for permitting wide deviations, hence the probable need for a special diode. But even so, the modulating signal (audio) must be a full 1-volt or more to get any "loudness" in the transmitter output. Low level signals like those straight from a microphone will not adequately modulate the oscillator.

Range of the Transmitter is extremely variable, depending on how you build and adjust the unit, as well as how high and long the antenna. Under ideal conditions with the Transmitter mounted on the roof of my house and a 20" antenna, I was able to listen to sounds around my property quite effectively over about a 1-block radius, using just a handheld scanner. Bear in mind that range is not always a desirable commodity. You don't want the rest of the world monitoring your "personal bugs", do you? Length and positioning of the antenna is a big determinant of range. You will want to experiment.

The SuperSnoop Transmitter is designed for DC power from +9v. I suppose you could use somewhat higher or lower voltages with no ill effect, but don't stray too far from specification.

VARACTOR DIODES of the hyper-abrupt type are not commonly available, but can be purchased from COMMtronics Engineering for $15.00 ppd. See Reference Information at the top of page 1 for contact information. Try the cheaper ECG/NTE 617 or 618 varactor diodes first, though.

CAVEATS

You didn't think we'd fail to issue a caveat or two, did you? The biggest one is that of bugging, which is probably **illegal** as hell. My SuperSnoop Transmitter and related projects are not presented with the idea of your using them as "bugs", though if miniaturized and concealed, they might well make better bugs than what the pro's use. Instead, these projects are specified to be for testing and evaluating your scanners, and perhaps for use as high quality baby monitors, peripheral property monitors, and legitimate things like that. If you are into doing bugs, do them at your own risk with the under-standing that if you're caught, you could face incarceration and/or stiff fines.

The device could also be illegal in the sense of violating FCC rules. Normally, it should not be if the input power is kept under 100-mW and if the antenna is kept short to 10" or less. Still, I am not a lawyer and I can't tell you what is legal or illegal. You and your attorney (or a judge and jury will have to determine that unique aspect. I just warned you that this puppy ***could be illegal***, depending on how and where it is used. Use common sense and discretion with these devices to keep out of the slammer.

NEXT MONTH ?

Next month, we will tie all three SuperSnoop circuits together into one powerhouse of a wicked little device. Meanwhile, I urge you to build and test these circuits independently as separate devices. The practice of building the separate devices for their separate uses will pave the way for my integrated system to come next month. You can then connect them together for an idea of what my total system will be like. But for now, each circuit can have unique little uses as independent devices.

Like the Transmitter, for instance. You can use it as a "repeater" by feeding the audio from a radio, hi-fi, or base scanner into the input. Then, as you work in the yard or around the house, just carry a handheld scanner strapped to your waist with an earphone to enjoy your program source while you're on the move.

MEMORY RETENTION CIRCUIT FOR THE PRO-2004/5/6 EXPLAINED!

ED NOTE: *This is a rehash of and take-off from a similar article in V5N2.*

Over the years, I have seen a number of memory retention problems associated with these fine scanners. You may as well know something about the circuit and how it works. Troubleshooting and repair are relatively easy if you know what to look for and how to test the components. The circuits are simple and the components are few.

Memory retention circuits are required for these scanners because they use Static Random Access Memory (SRAM) chips. Lesser scanners use EEPROM memory chips or on-board EEPROM inside the CPU chip. Actually, EEPROM is the hot memory chip these days because it requires no battery or other parts to preserve memory. The side effect is that EEPROM chips can't hold a lot of data yet, and they're expensive. Megamemory scanners still use SRAM that requires a constant voltage for "keep alive".

This "keep alive" voltage has to be present at all times, whether the scanner in ON or OFF and whether it is connected to power or not. The method by which this is accomplished is reliable, effective, simple, and inexpensive.

This discussion will use the PRO-2006 as a model, but the circuits for the PRO-

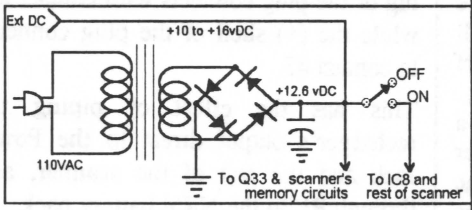
2004 and 2005 are all the same. The circuits for the PRO-2035 and 2042 are not the same, but are close enough that this discussion may suffice for them, too. The text of this article uses circuit symbols for the PRO-2006, so don't get confused.

Memory retention circuits for these scanners consists of a few well placed and selected components:

Battery
Switching diode
Current limiter resistors
CMOS voltage regulator
Filter capacitors for voltage regulator
Switching transistor
Noise filter capacitors

Now for a quick explanation of how the Memory Retention circuit works.

PRELIMINARY: Whenever the PRO-2004/5/6 scanners are plugged into AC or DC power, they are never fully turned off, even if the switch is off. See the below sketch of a typical power supply:

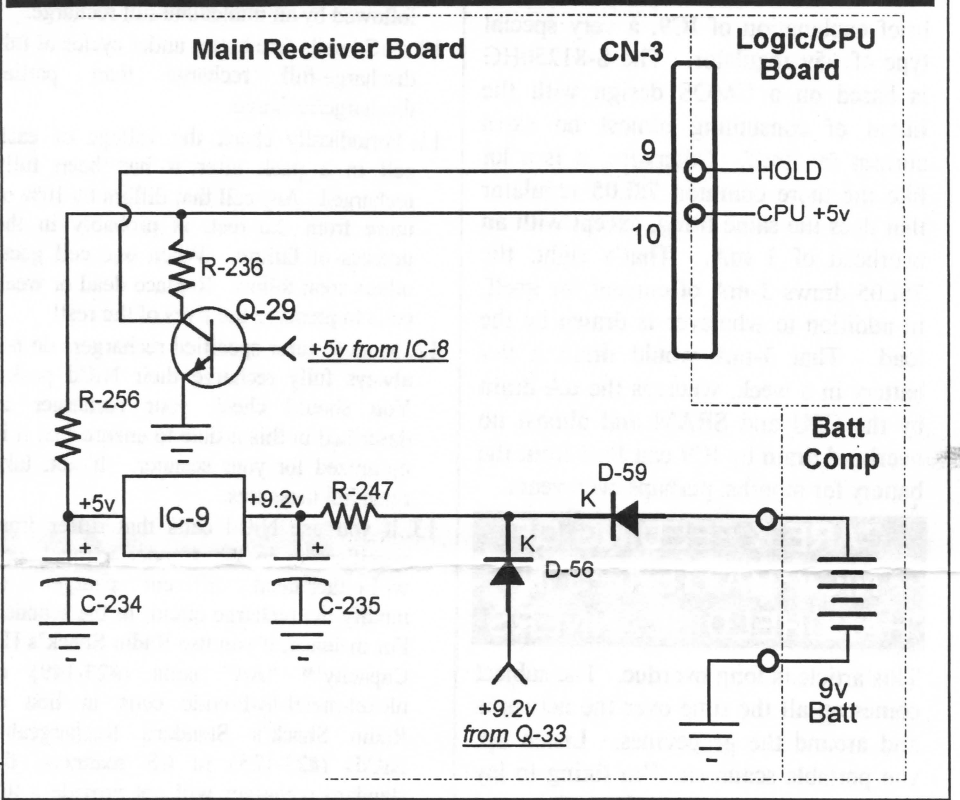


It can be seen how either an AC feed or an external DC supply will provide power to the memory circuits even if the scanner is turned off. Therefore, the only circuits of critical concern are those with the purpose of retaining memory when there is neither AC nor DC power connected to the scanner. The large schematic at the top of this page shows how it is done in the PRO-2004/5/6.

Whenever AC or DC power is connected to the scanner, Q33 produces and feeds about +9.2v through D56 to R-247, a current limiter for CMOS regulator,. IC9. Obviously, this +9.2v is regulated to +5v and fed to the CPU and SRAM.

Now let's back up to the cathodes of D56 and D59. The +9v from the Memory Battery feeds through D59 to meet the +9.2v through D56, right? Well, theoretically, yes. In actuality, no. Take a closer look. If +9.2v from Q33 is present on the cathodes of D56 and D59, and if +9v is on the anode of D59, then D59 cannot possibly conduct because it is ***reverse biased***! Well, when D59 cannot conduct, then the faucet for the Memory Battery is effectively turned off!

MEMORY RETENTION CIRCUIT FOR PRO-2006 (and PRO-2004/5)



The battery will sit there forever under that circumstance, doing absolutely nothing, all the while Q33 produces power for the CPU.

Remember, Q33 produces +9.2 volts any time and all the time the scanner is powered, either by AC or DC, no matter whether the scanner is on or off.

The story takes a turn when AC or DC power is lost or removed from the scanner. *Q33 goes dead with no power*! IC9 would then fail to provide power to the CPU, except for the simple diode logic of D59 and D56! When Q33 goes dead, D56/D59 cathodes drop to 0-v. Cool, because the battery's +9v is on the anode of D59. D59, therefore, becomes forward biased (*the faucet opens*) and allows battery power to pass to R247 and IC9, which don't care where power comes from! The CPU and SRAM draw very little current in their "sleep" states, and so the battery can maintain memory for months, if need be.

"Sleep" states? Well, yes, the CPU has one to preserve it's internal memory when there is no external power. It needs only a little squirt of memory battery power to stay ever at the ready when power is reapplied.

This "sleep" state is triggered by the HOLD signal that's generated by Q29 in the above diagram. The key thing is at the base of Q29 where a voltage is applied from IC8, the scanner's normal +5v regulator. IC8 turns on and off as the scanner is turned on and off. Therefore the base of Q29 has either +5v or 0v, depending. Q29 cannot conduct when the base is 0v and always conducts when the base is at +5v.

When Q29 is off or not conducting, and when memory power is available from IC9, then the voltage at the collector of Q29 through R236 is +5v. This +5v is passed to the CPU HOLD function via CN3, Pin 9. When Q29 is on or conducting, then the voltage at its collector drops to 0v, and is passed to the CPU HOLD function in the same fashion. Therefore, a "low" or 0-v to the CPU HOLD pin tells it all is well and to kick into high gear. Conversely, a "high" or +5v on the HOLD pin tells the CPU to drop into a deep sleep to conserve memory and power.

The HOLD signal clearly varies with the status of the scanner and whether it is turned on or off. In a word, the CPU drops into "deep sleep" when the scanner is turned off, and when there is no power to the scanner. Memory is preserved in the CPU and SRAM so long as IC9 provides +5v to the CPU and SRAM.

This article is not complete without a brief explanation of IC9, a very special type of +5v regulator. The S-81250HG is based on a CMOS design with the intent of consuming almost no extra current for itself. Otherwise, it is a lot like the more common 78L05 regulator that does the same thing, except with an overhead of 3 mA. That's right, the 78L05 draws 3-mA of current for itself, in addition to whatever is drawn by the load. That 3-mA would drain a 9-v battery in a week, whereas the μA drain by the CPU and SRAM and almost no overhead drain by IC9 can feed from the battery for months, perhaps even years.

CARE & FEEDING OF NiCd BATTERIES IN HANDHELD SCANNERS

This article is long overdue. The subject comes up all the time over the networks and around the grapevines. Listen up, you portable scannists: I'm fixing to lay the good words on you from the good book on *Care and Feeding of the NiCd Batteries In Your Handheld Scanners.*

First how about some easily chewed and swallowed ***brass tacks facts***?

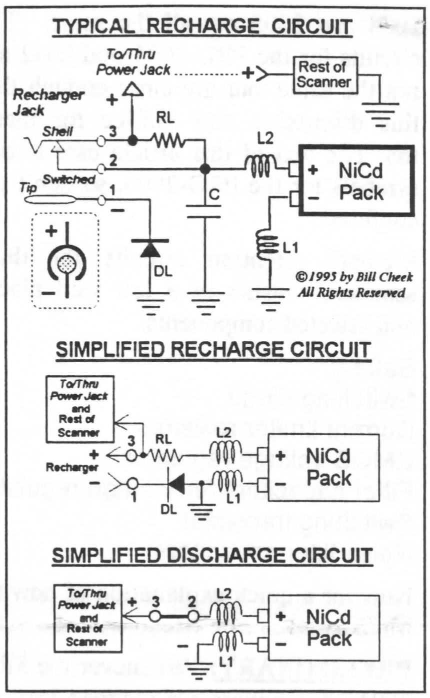
1. NiCd batteries do not have the legendary "*memory effect*". This myth was disproved by a NASA study over ten years ago. Forget it. Follow these "rules", instead.
2. A NiCd cell is ***fully charged at* 1.44 volts.** Any more than that and it could become damaged. A safe maximum recharge point is 1.40 volts per cell.
3. The (*nominal*) half-charge level of a NiCd cell is 1.20 to 1.25 volts per cell. This is the usually published rating. Its only meaning is "half" or median charge.
4. A NiCd cell is considered to be ***fully discharged*** at **1.0 volts**. It could become damaged if discharged below that level.
5. The maximum safe recharge rate of a NiCd cell is $^1/_3$ of its ampere-hour (A/h) rating or milliampere-hour (mA/h) rating. (*This is the fast charge* ***C3 rate***)
6. The safe trickle (maintenance) recharge rate of a NiCd cell is $^1/_{10}$ of its ampere-hour rating. (A/h or mA/h). (*This is the trickle or maintenance charge* ***C10 rate.***)
7. NiCd cells may be damaged or destroyed by excessive heat, defined as more than mildly warm to the touch. Cold will usually not harm a NiCd cell, but it should not be operated below freezing.
8. NiCd cells can self-discharge at a rate of up to 1% per day. Periodically recharge stored NiCd cells.
9. It is a good idea to periodically discharge seldom used NiCd cells to 1.0-v per cell followed by an immediate full recharge.
10. NiCd cells fare better under cycles of full discharge-full recharge than partial discharge/recharge.
11. Periodically check the voltage of each cell in a pack after it has been fully recharged. Any cell that differs by 10% or more from the rest, is probably in the process of failure. When one cell goes, others soon follow. Replace dead or weak cells to preserve the lives of the rest!
12. Manufacturer-specified rechargers do not always fully recharge their NiCd packs. You should check your recharger as described in this article to ensure that it is optimized for your scanner. If not, take remedial measures.
13. If you use NiCd cells that differ from specification in the scanner manual, you will either need a different recharger or to modify the recharge circuit in the scanner. For instance, if you use Radio Shack's Hi-Capacity™ "AA" cells (#23-149) or nickel-metal-hydroxide cells in lieu of Radio Shack's Standard Rechargeable NiCds (#23-125) in RS scanners, the standard recharger will not provide a full charge. This defeats the purpose of costlier hi-performance cells.
14. A NiCd pack can only recharge up to a value that's equal to the recharger terminal voltage less the sum of all voltage drops in the recharge circuit. If the resultant voltage is less than 1.40v per cell, then the pack cannot fully recharge.

Ok, this about sums up what it takes to care for and feed your NiCd powered handheld scanners. In general, the above rules apply to all NiCds, no matter where they're used, but this article focuses on the unique needs of NiCd cells as used in handheld scanners.

The above drawing accurately depicts the recharge circuit used in most handheld scanners. There may be minor differences from one scanner to the next, but they are not substantial.

The illustration also shows simplified versions of that circuit so you can see it as it counts, even if you don't read schematics very well. It is important that you understand the circuit so that you can take remedial measures as needed by your particular scanner!

A scanner's recharge circuit is really two circuits in one, when you consider that it has to recharge by one path and discharge or power the scanner by another. The key ingredient here is the ***switched*** RECHARGE JACK.



When the recharger plug is inserted into this jack, it moves contact #2 so that it can't touch contact #3. The (-) center lug of the plug connects with contact #1, while the (+) shell of the plug connects to contact #3.

This has the effect of piping the recharger's output direct to the Power Jack and the rest of the scanner, and through RL to the NiCd battery pack. In a word, the recharger can power the scanner and recharge the battery at the same time. *Not recommended, though!*

Meat 'n taters: The recharge path is through DL & L1 into the battery, and out through L2 and RL. Simply stated, the recharge current goes through DL, L1, L2 and RL, and drops a voltage across each of these components! Take note, because ***this is important.***

Now consider that L1 and L2 are chokes or coils, and that their resistance is probably well below 1-Ω, so we can discount their effect on the circuit. L1 and L2 are there to block sharp voltage spikes from entering the battery, but not to affect the recharge action. That leaves RL and DL to evaluate, and these are very important considerations to the proper recharging of your NiCd pack.

No matter the output of the recharger, *diode DL drops 0.6-volt off the top.* RL drops an additional voltage equal to the current flow through it, multiplied by its resistance. Suppose the NiCd pack is fully charged and is drawing a trickle charge (**Rule 6**) of 45-mA.

If RL is 22Ω, then the volts dropped across RL = 0.045 × 22 or 1 volt. Add the RL-drop to the 0.6v DL-drop for a total drop of 1.6v. Now suppose the NiCd pack has 6-cells. **Rule 2** says 1.40 × 6 = 8.40 volts. In order for the NiCds to receive a FULL charge, the recharger ***better*** put out 8.40 volts plus the sum of all drops (1.60v): *exactly 10 volts*! Any less, and the NiCds will never fully charge. Any more, and they could be damaged or have a shortened life span.

Now don't get excited if there is a tenth of a volt difference, one way or the other. That small difference is not a concern. If more , however, there could be trouble.

What if your recharger is not up to par? Well, you can usually fix it, but not like you'd think. For one thing, the actual recharger is probably ok. It's the recharge circuit in the scanner that needs the fixing. But first, let's lay the groundwork for how to be absolutely certain of the quality of your recharger and recharge circuits

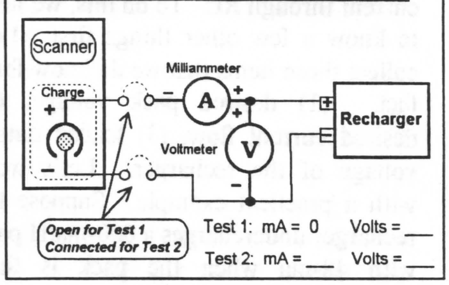
It all begins with a thorough understanding of ***The Rules*** given on the previous page. Even if you don't understand them, you must abide them!

The first step to assess the quality of your recharger system is to start with a ***new set*** of NiCd cells. If you test with an old set, that can't accept a full charge of 1.40-1.44v per cell, you really won't know if the recharger is faulty, or if the cells are just too old and decrepit. ***You can perform the simple test on a old set of NiCds, and if they test up to a full charge, then well and good.*** Older cells usually do not fully recharge, though, so it's best to start with a new set.

1. Charge or recharge a new NiCd pack for at least 18-hrs to ensure that it has charged all that it's going to.
2. Remove the NiCd pack from the scanner or charger and immediately measure and record its terminal voltage without anything connected to it. Ideally, it will show 1.40v to 1.44v per cell. (*A 6-cell pack should be 8.4 to 8.6 volts.*) If so, all is well; you can stop here. If not, a remedy is strongly suggested. Here's how:
3. Measure and record the voltage of the recharger without it connected to anything. This is called "open circuit" or "***no-load voltage***". (*See **V** in the above drawing.*)
4. Connect the recharger back to the freshly charged NiCd pack, and again measure and record the voltage of the recharger. The voltage will be less than the no-load measurement. This is called "***voltage under load***". (*See **V** in the above drawing.*)
5. Use the milliammeter function of your meter to measure and record the current flow. (*See **A** in the above drawing.*) The current flow into a fully charged NiCd pack should not exceed one-tenth the mA/h rating of the pack *when fully charged*.

NOTE: Most handheld scanners use "AA" cells, which can have mA/h ratings of 450 to 1000 mA/h, depending on the brand and type of cell. Current flow should be 45-mA for 450 mA/h cells and 100-mA for 1000 mA/h cells. I have seen "AA" NiCd cells in 450, 600, 650, 800, and 850 mA/h capacities. Nickel-metal-hydride "AA" cells can go to 1000-mA/h.

RECHARGER QUALITY ASSURANCE TEST



We have two important considerations here: **(1)** the terminal voltage of a fully charged pack must not exceed 1.44v per cell, nor be appreciably less than 1.40v per cell, and **(2)** the safe maintenance or trickle charge for a fully charged pack should be equal to $^{1}/_{10}$ the mA/h rating (C10) of the pack. (*The "C" rating of one cell is the rating of the entire pack.*)

If the full charge pack voltage does not meet spec per Step 2, then chances are the charge current measured in Step 5 is too low (less than the C10 rating). The remedy for this is to increase the current just enough to meet the C10 rating but not to exceed it. To do this, the series limiter resistor (RL) in the scanner needs o be dropped to a lower value. So how to calculate it?

6. First, understand that the present *NiCd pack voltage* + the diode drop (*0.6v*) + the RL drop (*current × resistance*) = the *recharger loaded output voltage*.

The only thing we can alter to change the pack voltage is the resistor. So we calculate a new value of RL as follows:

$RL = E_{drop} \div I_{flow}$ where E_{drop} is the voltage dropped across RL and I_{flow} is the current through RL. To do this, we need to know a few other things first. Lets collect those items that we do know for a fact. (1) desired pack voltage, (2) desired current flow, (3) loaded output voltage of the recharger. Let's work with a practical example. Suppose the recharger undercharges a 600-ma/H pack with 48-ma when the pack is fully charged to 8.32 volts.

We want:

Desired pack voltage = 8.40v-8.60v
Desired trickle charge = 60-ma

We have:

Loaded recharger output = 10.5 volts
Resistor RL = 33Ω
Trickle charge = 48-ma
Fully charged cell pack = 8.32 volts

We calculate:

$\mathbf{E_{drop} = I_{flow} \times RL}$
$\mathbf{E_{drop} = 48\text{-}ma \times 33\Omega} =$ 1.58 volts
$\mathbf{Total_{drop} = E_{drop} + Dl_{drop}}$
$\mathbf{Total_{drop} = 1.58v + 0.6v} =$ 2.18 volts
Net Volts to Pack = 10.5 - 2.18 = 8.32v

Yup, so far, so good. Everything checks out to be reasonable. So now we need to replace RL with a lower value to allow an $\mathbf{I_{flow}}$ of 60-ma. We do this by selecting a final full recharge voltage for the pack....let's be conservative and choose 8.50 volts....halfway between 8.4 and 8.6 volts. First, we assume that the recharger loaded output voltage won't change and will remain at 10.5-volts. Now follow my logic here:

If the recharger output is 10.5v and we want 8.5 volts ($\mathbf{E_{Final}}$) to the cell pack, then the sum of all drops must be 2.0 volts. The diode DL will always drop 0.60 volts so that leaves 1.40-volts for RL. We want a trickle charge ($\mathbf{I_{flow}}$) of 60-ma, so now we can calculate a new value of RL:

$\mathbf{RL_{New} = (E_{drop}) \div (I_{flow})}$
$\mathbf{RL_{New}} = (1.40\text{-v}) \div (0.060\text{-amp})$
$\mathbf{RL_{New}} = 23.3\Omega$

Cool! Just happens that 22Ω is a common resistor value. Replace the 33Ω RL in your scanner with a 22Ω resistor, and your NiCd pack should stabilize at a higher voltage, closer to the ideal max!

There you have it....all the tools to ensure the health and good feeding of your NiCd batteries. Do understand the foregoing is not an exacting science; rather it is an iterative process where trial and error lead to the optimum design for your particular scanner. If you have more than one scanner, the results will probably differ for each! But now you understand why manufacturers do things the way they do....keeps things simple...and mediocre.

ANOTHER PET PEEVE WINNER

Anonymous by Request: Phoenix, AZ

Hi Bill & Cindy: I need one of those PerCon CD-ROMs, so here's my attempt.....

My favorite gripe on our hobby is the press and their coverage and sometimes lack of coverage on our hobby. (The various rags that have ***some*** scanner coverage or ***only*** scanner coverage, I don't read the others) They all seem to make a huge attempt to stay away from stories that are even a little controversial. (*Read Interesting*) I have not seen one mention anywhere of Laura Quarantiello's two-facing of our hobby in "Police" Magazine. Only on the Internet Newsgroups could you find these types of stories. This only backs up your position of computers and our hobby, *you must own one!* I think these rags could make better attempts to cover different subjects each month. If you read one, you've read them all. Even the tech articles in some seem to be sometimes almost the same from one to the next. I won't ramble on, you get the idea, most of these magazines are all the same. I enjoy the WSR a great deal. The almost totally technical format is exactly what I like. Thanks ☺

WE'RE LATE & BEHIND

But we'll be catching up. Apologies to all those who have been inconvenienced by the delays. A combination of health problems and an overload of work conspired to put us behind. Not to worry, every subscription is guaranteed to receive the proper number of issues. There are two more to go for the 1995 calendar year, and we'll be working overtime to get them out, hopefully this month. Do NOT be concerned by the expiration date on your mail label if it says **"11/30/95"**....you'll still receive all issues.

WHAT'S NEW?

I don't know where to begin.....Let's start with the Internet. We are now represented on the World Wide Web with a ***"home page"*** and an ***FTP site***!

Our WWW page address is **exactly** as follows:
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Our FTP site can be reached with an FTP client program or Unix shell account **exactly** as follows
cts.com/usr/spool/ftp/pub/bcheek

If your *WWW Browser* supports FTP, the address is:
ftp://ftp.cts.com/pub/bcheek

I'll tell you more next issue, but for now check out these sites and let us know what needs improvement.

Mark my words, ***the Information Age has dawned!***

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+ Memory Retention Circuits of PRO-2004/5/6 Explained
+ ***Care & Feeding of NiCd Cells in Handheld Scanners***
+ Another Pet Peeve Winner Announced!
+ We're Late and Behind - but Catching Up.
+ ***What's New? We're on the Internet - Big Time!***

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